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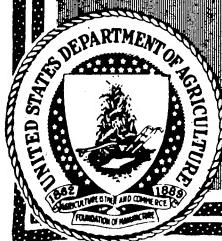
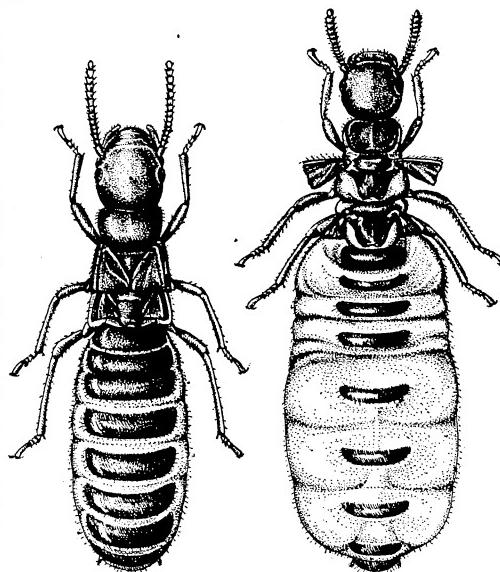
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July 1934

PREVENTING DAMAGE BY TERMITES OR WHITE ANTS

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THROUGHOUT the United States, but especially in the Southern, Central, Southwestern, and Pacific Coast States, native termites, or white ants, cause serious damage to the foundations and woodwork of buildings and articles in the buildings, and to living trees, crops, and other vegetation. Damage to buildings, furniture, and similar articles can be prevented by the proper construction of buildings and the chemical treatment of wood, and injury to growing vegetation can be reduced by clean culture and the use of insecticides.

This bulletin describes the habits and activities of subterranean and nonsubterranean termites and sets forth in detail the precautions to be taken against them and the remedies available when damage has been done.

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PREVENTING DAMAGE BY TERMITES OR WHITE ANTS

By T. E. SNYDER, senior entomologist, Division of Forest Insects, Bureau of Entomology

CONTENTS

	Page
Termites and their habits.....	1
Distribution and forms.....	1
Location of colonies or nests.....	1
Termites that are subterranean in habit.....	2
Termites that are nonsubterranean in habit.....	5
The colonizing swarm.....	5
The reproductive forms.....	5
Preventing and remedying damage to wood-work of buildings.....	7
Destruction of breeding places about the building site.....	7
Proper construction of buildings.....	8
City building codes.....	14
Locating and temporarily arresting the damage.....	15
Indications of infestation.....	16
Preventing and remedying damage to wood-work of buildings—Contd.	
Killing the winged adults will not stop the damage.....	16
Disconnecting wood from the ground.....	17
Replacing wood with concrete.....	17
Replacing wood with metal.....	17
Combating termites that are nonsubterranean in habit.....	17
Preventing and remedying injury to living vegetation.....	18
Fruit, nut, shade, and forest trees.....	18
Young plantations or nursery stock.....	19
Vineyards.....	20
Field and truck crops.....	20
Flowers and greenhouse stock.....	20

TERMITES AND THEIR HABITS

DISTRIBUTION AND FORMS

THE TERMITES, or "white ants", in this country are mostly destructive native insects. Fifty-six species of them occur in the United States. They are distributed throughout the country, although in the southern, southwestern, and Pacific coast regions, where both the subterranean and nonsubterranean kinds occur (fig. 1), they are more numerous and injurious than elsewhere.

These so-called "white" ants are not true ants, although they look like ants and live in colonies made up of different forms or castes. In these nests or colonies both wingless and winged mature individuals are produced. The brownish or blackish, elongate, slender, antlike, colonizing, sexual adults (fig. 2) with long white wings, unlike the other forms, have functional eyes, and their bodies are able to endure full sunlight. These migratory males and females appear normally once a year during a short period.

There are three stages in the life of termites—the egg, the nymph, and the adult. The adults are of two kinds—sterile and fertile. The sterile adults of our common subterranean termites and of many other species include two forms (or castes)—the soldiers (fig. 3, *a*) and the workers (fig. 3, *b*); and the fertile or sexual adults include three normal forms (fig. 4, *F* to *K*).

LOCATION OF COLONIES OR NESTS

The nests of some species of termites¹ are in the earth and in dead and decaying wood. These more common and injurious species are of subterranean habit, timber and trees being attacked by the workers only through the ground. The nests of some other less common species,² however, are excavated in wood and trees by the winged forms, there being no workers and no underground life.

¹ Genera *Reticulitermes* Holmgren, *Heterotermes* Froggatt, *Amitermes* Silvestri, etc.

² Genera *Termopsis* Heer, *Kalotermes* Hagen, *Neotermes* Holmgren, *Cryptotermes* Banks, etc.

With the clearing of land and the consequent destruction of their natural breeding places in the dead trees, decaying stumps, and logs of the forests, termites become increasingly destructive to the wood-work and contents of buildings (figs. 5-11), telephone poles, fences, or any timber in contact with the ground, as well as to living vegetation, including not only fruit and shade trees, shrubs, and flowers, but also truck (fig. 12) and field crops and, in California, grapevines. The principal food of termites is cellulose, which they obtain from either dead or living vegetation.

Termites in the United States are mainly species of subterranean or wood-boring habit and are not so spectacular or common as the mound-making or tree-nesting termites of the Tropics. Very few termites in this country have habits that make them conspicuous, or come above ground into the sunlight except during the annual coloniz-

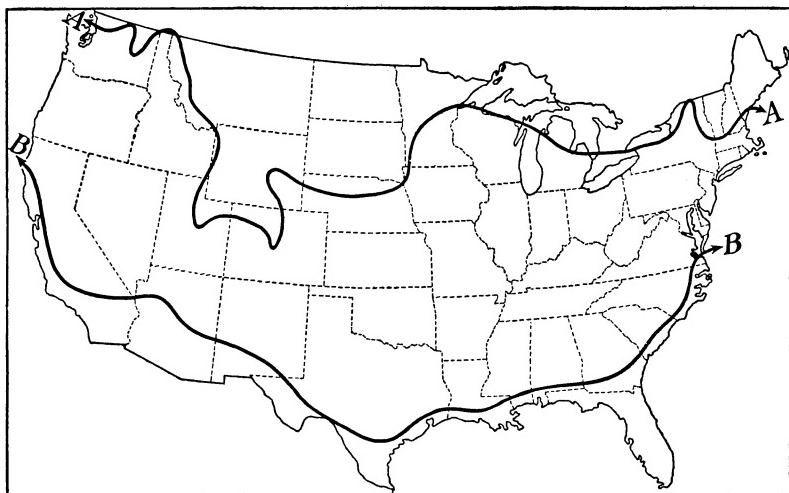


FIGURE 1.—Map showing (line A-A) the northern limit of damage done by subterranean termites in the United States and (line B-B) the northern limit of damage done by dry-wood or nonsubterranean termites.

ing swarm; hence they largely escape notice until they become injurious.

TERMITES THAT ARE SUBTERRANEAN IN HABIT

Subterranean termites live in forests, building their nests in the wood of standing timber, logs, or stumps; in cleared land, in any wood in contact with the ground; or, in the plains, in a labyrinth of underground passages in the earth, usually underneath wood or vegetation.

Termites are soft-bodied and always conceal themselves within wood, in the earth, or within their earthlike carton shelter tubes (fig. 13). The grayish-white, soft-bodied, wingless, sterile "workers" (fig. 3, b) are in reality the destructive form. These workers make the excavations occupied by the colony and enlarge and extend them as the colony increases. They live underground or within the wood, are blind, and shun the light; as a result they are rarely seen. In burrowing through wood the workers often completely honeycomb it, usually following the grain and eating out the softer, thin-walled,

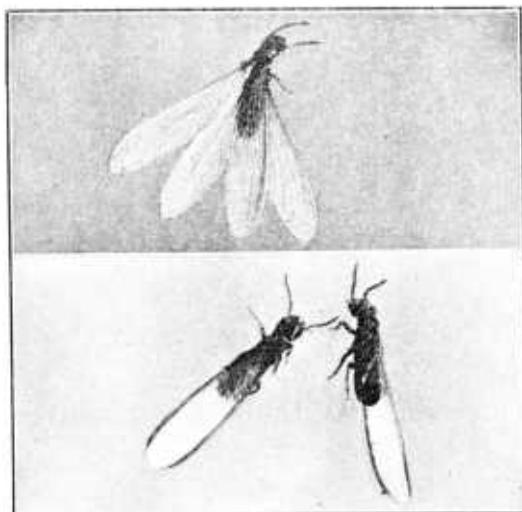


FIGURE 2.—Winged sexual adults of eastern subterranean termites; upper, *Reticulitermes virginicus*, nearly three and one-half times natural size; lower, *R. flavipes*, three times natural size.

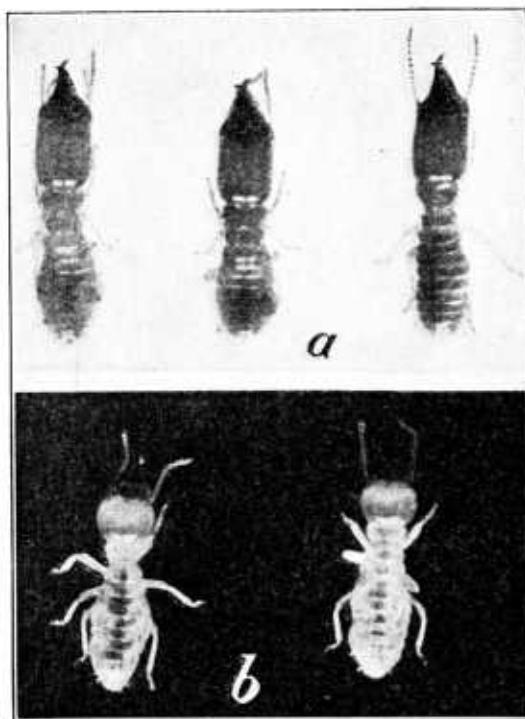


FIGURE 3.—Mature soldiers (a) and immature workers (b) of the eastern subterranean termite *Reticulitermes flavipes*. Slightly more than six times natural size.

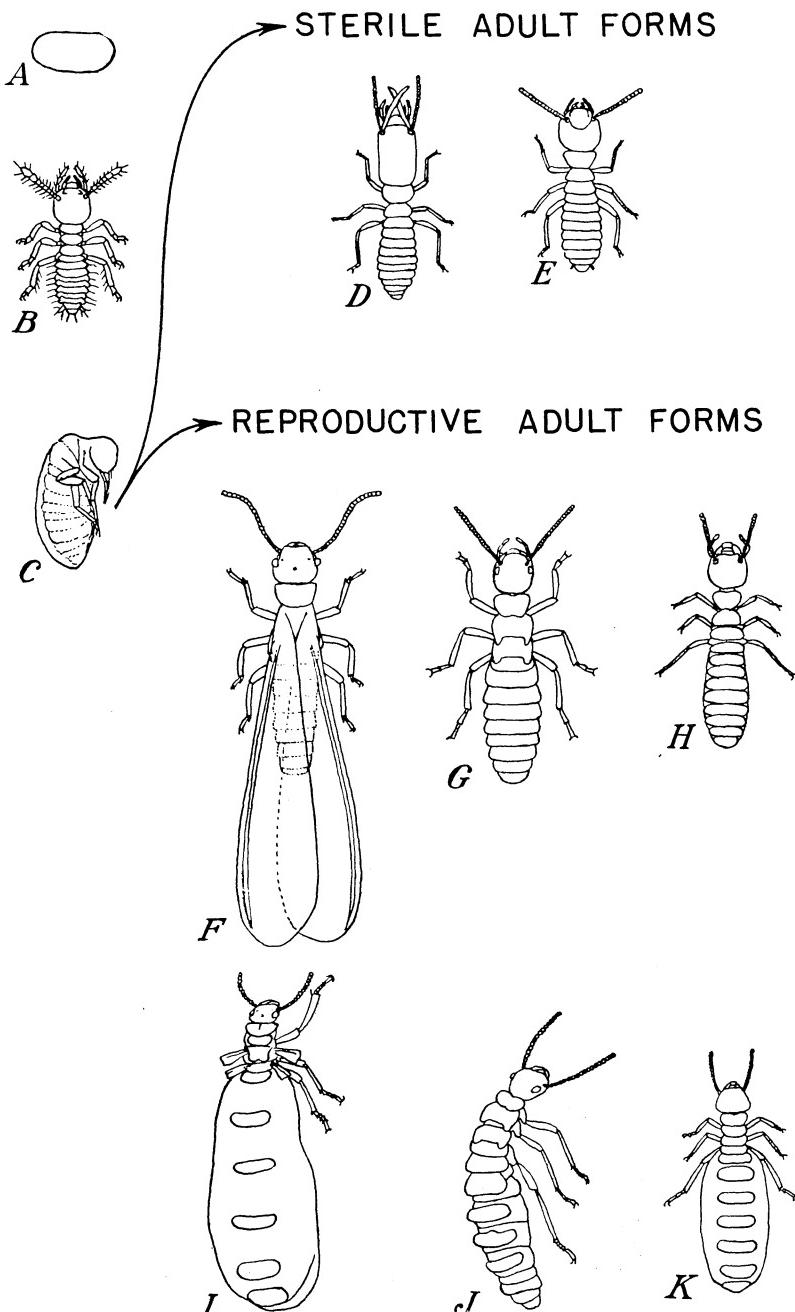


FIGURE 4.—Diagram showing the relationships of the stages and forms of our common subterranean termite *Reticulitermes flavipes*: *A*, Egg; *B*, recently hatched nymph; *C*, mature nymph in quiescent or resting stage; *D*, soldier; *E*, worker; *F*, sexual winged adult; *G*, sexual adult with wing pads; *H*, workerlike wingless sexual adult; *I*, *J*, and *K*, enlarged egg-laying females or queens, corresponding to *F*, *G*, and *H*, respectively. *D* and *E* are sterile adult forms; *F*, *G*, *H*, *I*, *J*, and *K* are fertile or reproductive adult forms. (The enlargements are approximately as follows: *A*, $\times 16$; *B*, $\times 13\frac{1}{2}$; *C*, $\times 10$; *D*, $\times 4\frac{1}{2}$; *E*, $\times 5\frac{1}{2}$; *F*, $\times 6$; *G*, $\times 4\frac{1}{2}$; *H*, $\times 5$; *I*, $\times 2\frac{1}{2}$; *J*, $\times 2\frac{1}{2}$; *K*, $\times 3$.)

larger-celled spring or new wood. They are able to penetrate the hardest of woods, provided they have access to moisture in the ground. In extending their galleries in wood and vegetation, subterranean species carry moisture with them by means of moist excrement mixed with earth.

TERMITES THAT ARE NONSUBTERRANEAN IN HABIT

The nonsubterranean termites which are injurious attack wood directly; but, instead of following the grain continuously, they excavate through it longitudinal chambers of limited length. The sexual adults, after they have lost their wings, and the young or nymphs, are the destructive forms. Their pellets of excrement (fig. 14) are regularly impressed, and sometimes completely fill or block up the burrows in a compact mass; they are often expelled as dry droppings from the infested wood. These termites are destructive to the woodwork and furniture in buildings (fig. 15), as well as to living trees. Apparently they can exist without the great amount of moisture necessary to the life of termites which are subterranean in habit.

THE COLONIZING SWARM

At certain seasons, usually spring or fall, but varying with the species and the locality, the winged, sexual individuals migrate in large numbers from the parent nests. They then lose their wings and breed new colonies. In the case of the subterranean termites, wood and trees are usually entered indirectly through the ground, although sometimes these insects enter trees under bark loosened by sunburn, etc., or through scars or borer holes, provided sufficient moisture is present. Nonsubterranean termites enter the wood directly, or, in the case of trees, through wounds or borer holes or under loose bark; moisture is not necessary.

In the new quarters eggs are laid, the young develop, and in a few years the colony increases in numbers, and the workers are able to feed and care for the reproductive forms—the “king” (title page, left) and “queen” (title page, right)—as well as the soldiers (fig 3, *a*), which are sterile forms adapted to protect the colony from insect enemies, notably the true ants. In recently formed young colonies the rate of egg laying is slow, but mating is repeated, and, although there is at first a gradual increase, later the increase in the numbers of the broods is rapid. In old colonies there are thousands and tens of thousands of individuals.

Egg laying occurs over a considerable period during the warm months in colonies out of doors. In infested buildings artificially heated, where an even temperature is maintained, the insects are active and may lay eggs every month of the year. The number of eggs laid depends on the age of the queen.

THE REPRODUCTIVE FORMS

Owing to the increasing number of eggs that develop within her the queen becomes enlarged, but never loses the power of locomotion. It was once believed that, since the queen mother was the source of the colony life, the termite colony would be exterminated if she were destroyed, but this has been disproved by more recent studies. In addition to the forms that have shed their wings, several different types of reproductive forms occur—forms with wing pads (the undeveloped wings of the nymphs) and wingless reproductive adults.

The winged forms, however, are the normal type and occur as a single pair, whereas there may be hundreds of the other forms heading colonies. The reproductive forms with wing pads and the wholly wingless type usually have little color in the body, and the eyes are

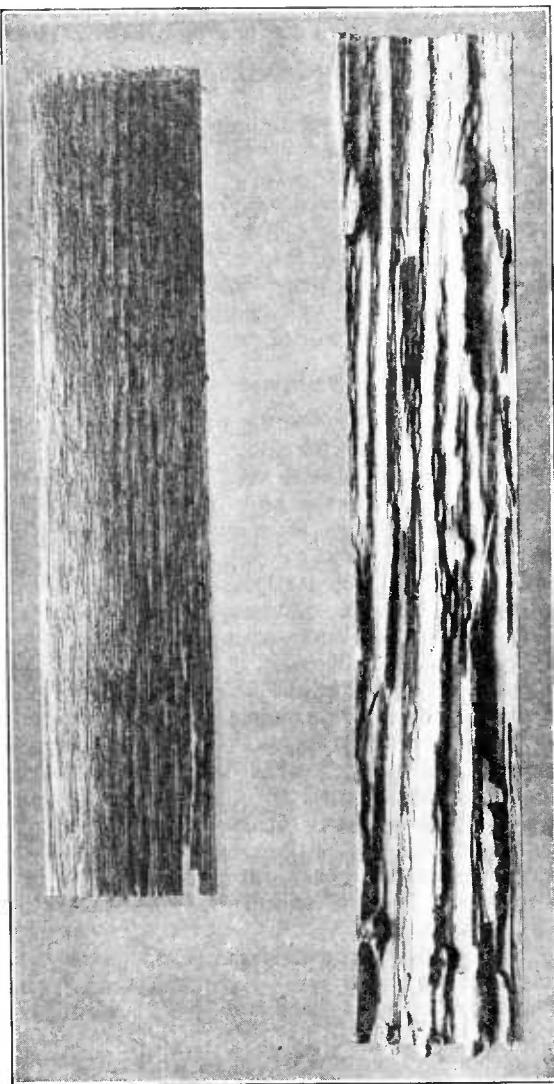


FIGURE 5.—Damage to oak flooring done by the common eastern subterranean termite *Reticulitermes flavipes*. Note that damage is not apparent on the upper surface.

small. These forms rarely come aboveground or leave the burrows in wood.

The location of the queens in the colony depends upon the season of the year. During periods of intense heat or drought in the Plains or in arid or prairie regions the subterranean termites burrow deeply below ground or to a less depth under stones, cow chips, etc. During the winter in the colder climates they burrow below the frost line.

Whole colonies of subterranean termites migrate when conditions become unfavorable. The nonsubterranean termites, on the other



FIGURE 6.—Quartered-oak flooring damaged by the subterranean termite *Reticulitermes flavipes* in an infested building, Washington, D.C., 1915.

hand, are not able to leave the wood in which they have excavated their nests.

PREVENTING AND REMEDYING DAMAGE TO WOODWORK OF BUILDINGS

DESTRUCTION OF BREEDING PLACES ABOUT THE BUILDING SITE

If buildings are to be constructed on recently cleared woodland, decaying logs and stumps should be removed from the soil in the vicinity and burned.

If, because of the presence of decaying wood and humus, the subterranean termites are numerous in the earth, the soil should be deeply plowed or otherwise broken up and treated with chemicals to kill the insects. Effective poisons for this purpose are a 10-percent

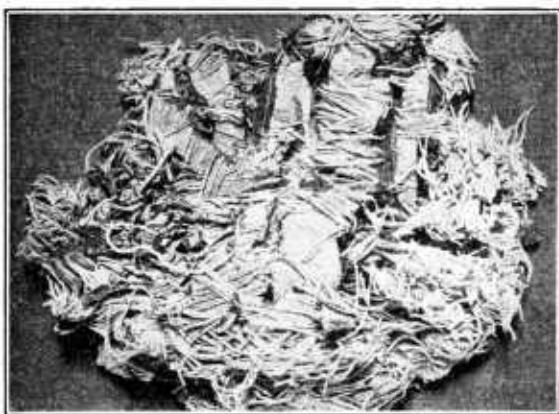


FIGURE 7.—Tube of coarse yarn from bale of cotton on floor of building infested by subterranean termites, Greenville, S.C.

solution of sodium arsenite;³ 1 part coal-tar kerosene oil (this mixture should be strained through burlap before

³ This poison is caustic and should not be used near living vegetation.

being used); carbon disulphide emulsion, which is on the market ready for use; orthodichlorobenzene (50 gallons per 1,000 square feet). Live steam forced into the soil will serve the same purpose as the gases. Decaying fence posts, sidewalks, etc., should be removed and replaced with treated wood, concrete, stone, or other resistant substances; such decaying material would facilitate the formation or perpetuation of the termite colonies.

PROPER CONSTRUCTION OF BUILDINGS

Termites will infest not only old buildings but also improperly constructed new buildings, and these are often badly infested. It is not the age of the building but the manner in which it has been constructed that renders it liable to attack.

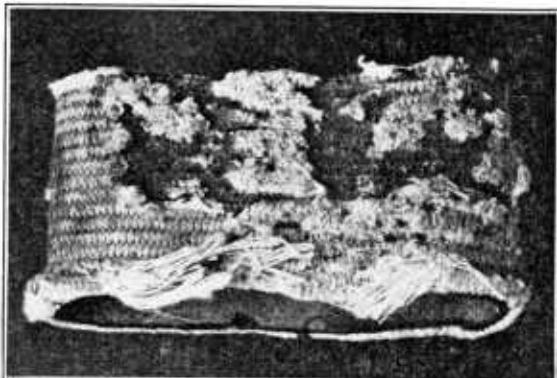


FIGURE 8.—Cotton jacket of rubber-lined fire hose from infested building in Missouri, damaged by subterranean termites (*Reticulitermes* sp.).

necessary for their existence. When contact with their moisture supply in the earth is cut off, the subterranean insects in the damaged wood, no matter how numerous, soon dry up and die.

FOUNDATIONS, SUPPORTS, ETC.

To prevent subterranean termites from reaching the woodwork of buildings from their nests in the ground, the foundations of buildings should be constructed, if possible, entirely of stone, brick, concrete, or concrete and steel,⁴ including the pillars in the basement or cellar. The walls, partitions, and flooring in the ground floor, basement, or cellar should also be of concrete. Wooden flooring can be laid over this concrete floor if desired. If the flooring is to be of concrete, the concrete should be laid on a gravel base.

In buildings where stone, brick, or concrete foundations are impracticable, timber impregnated with coal-tar creosote should be employed, and no untreated wood should come in contact with ground which may be infested with termites. Wood to be protected from termites should be impregnated with coal-tar creosote by either the cylinder-pressure or the open-tank process. Full details regarding

⁴ In the Southern States, especially in the subtropics, the more valuable permanent buildings should be constructed entirely of steel and concrete.

INSULATION

Complete insulation from the ground of all untreated wood-work of buildings is the only effective permanent remedy against attack by subterranean termites, and the only relief from their presence. These insects must maintain contact with the ground to obtain the moisture necessary for their existence.

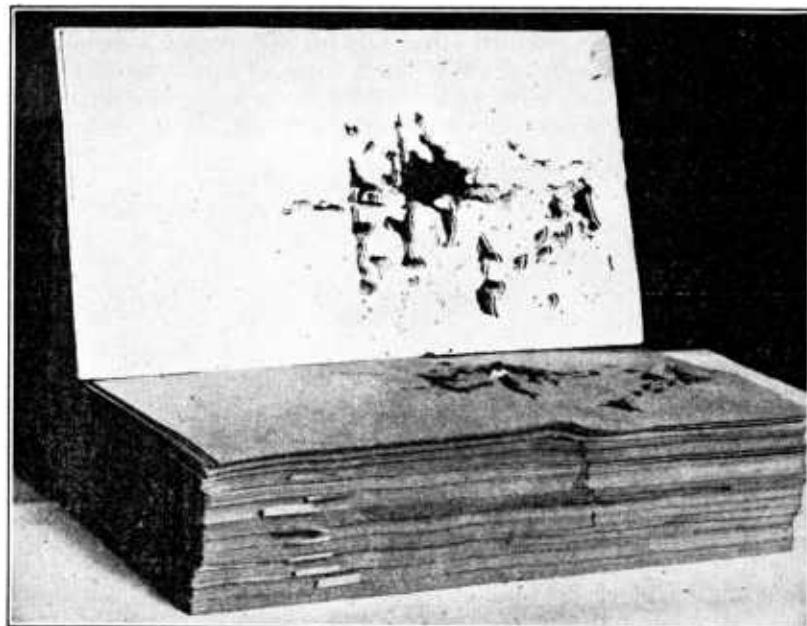


FIGURE 9.—Revenue stamps damaged by the subterranean termite *Reticulitermes flavipes* on infested flooring in the Bureau of Engraving and Printing, Washington, D.C., 1921.



FIGURE 10.—Correspondence and advertisement regarding issue of county bonds; damaged by subterranean termites infesting the building in Virginia in which they were stored.

these processes can be obtained from the United States Forest Products Laboratory, Madison, Wis. The open-tank process is simpler, can be made to give satisfactory results where properly used, and can be operated by unskilled labor. If for any reason neither of the foregoing processes can be used, three coats of hot coal-tar creosote brushed on the wood, with sufficient intervals between brushings to permit each coat to dry, will be fairly effective. This method, how-

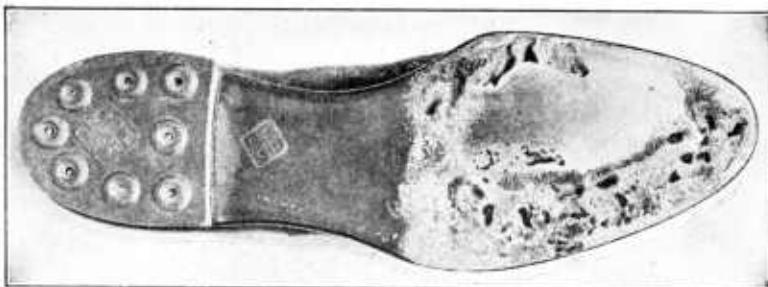


FIGURE 11.—Damage done by the subterranean termite *Reticulitermes flavipes* to shoe stored on infested woodwork in a building in New York City.

ever, is not generally recommended, since it will preserve the wood for only a few years.

The supports of porches or steps should never be laid directly on the ground, but should rest on rock or concrete. Window sills and frames in the basement or cellar should be laid over concrete and the woodwork should not come in contact with the ground. The supports of the woodwork of coal bins in basements or cellars should

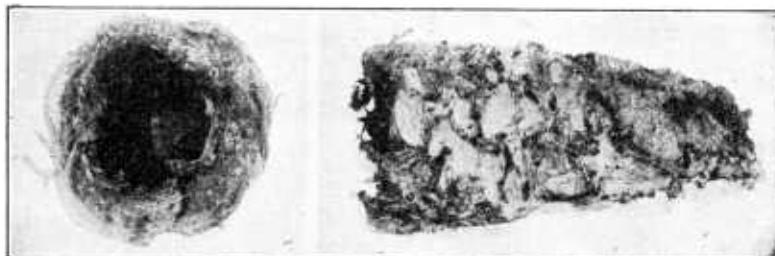


FIGURE 12.—Injury to carrots caused by the subterranean termite *Reticulitermes claripennis*, at Dallas, Tex.

not be set in the ground, but should rest on concrete, not extending through the concrete into the soil.

CONCRETE FLOORING

Even in permanent stone or concrete and steel buildings the concrete flooring is often constructed improperly. Usually the base of the concrete floor is a loose combination of coarse gravel or cinders and cement grout. This very rough conglomerate, even if several inches thick, has many cracks and large holes running through it. Over this is laid a layer of solid concrete about 2 or 3 inches thick, of fine texture, in which untreated wooden sleepers are laid while it is still moist. These sleepers nearly or quite reach the coarse, open

conglomerate in contact with the earth, and to them is nailed the wooden flooring (fig. 16, A).

It will be seen that this is faulty construction. Termites have free access from the earth, in which they have galleries, through the porous conglomerate, to the untreated beams and flooring. *There should be a layer of solid concrete at least 1 inch thick between the grout and the wood* (fig. 16, B).

Among the commonest means of infestation are wooden sleepers or stringers laid in concrete while the latter is still soft, or placed before

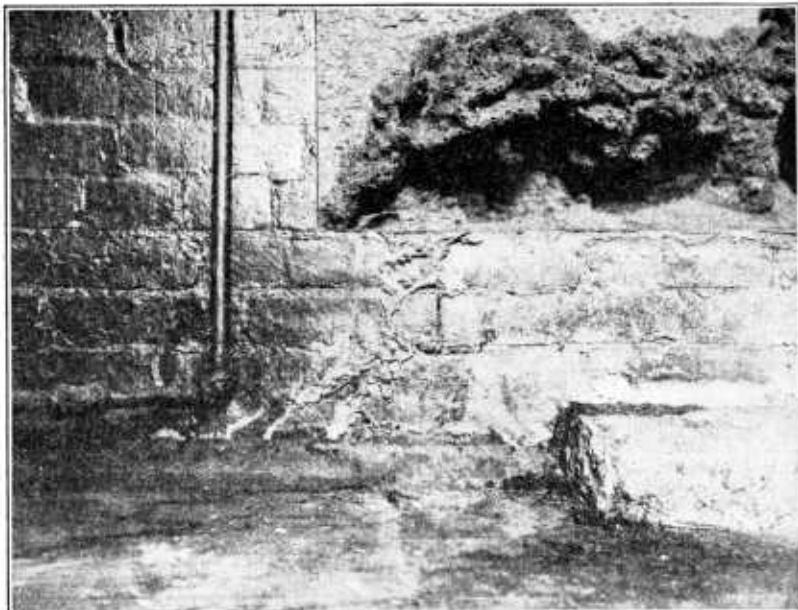


FIGURE 13.—Carton, earthlike, shelter tubes constructed by the eastern subterranean termite *Reticulitermes flavipes* over brick wall in dark, heated, damp basement; these tubes are used in passing over impenetrable substances. Inset, near view of tubes showing texture.

the concrete has been poured in. Termites enter through these wooden beams. Other common means of infestation are supports of coal bins extending through concrete and through the disintegrated lime mortar of brick walls.

TERMITE SHIELDS, GUARDS, OR METAL CAPS

Subterranean termites require constant access to soil moisture in order to attack wood. This requirement is supplied when wood is either in contact with the soil or when the termites can reach it through covered, earthlike shelter tubes. These shelter tubes may be constructed over the face of stone, concrete, or brick foundations and along water pipes or similar structures. In consequence they can be kept out of buildings by means of metal barriers. By firmly inserting a sheet of galvanized iron or "termite shield" in the surface of the masonry and letting it project horizontally for 2 inches, then turning the projecting part downward at an angle, communication of termites with the soil, where they obtain moisture, can be cut off. In

less pretentious frame buildings, metal caps should be placed over the tops of all construction stone piling or pillars.

This method is similar to that used in rat-proofing corncribs. It is effective and practicable where untreated timber is placed over masonry foundations.

Again, in the case of stone and steel buildings, the steel or stone pillars or piping extending down through the concrete floor to foundations in the earth often make infestation possible, owing to the fact that the concrete floor does not fit tightly about them. Overlapping strips of metal extending horizontally several inches from the pillars or pipes should be imbedded in the concrete floor in order to obtain

a tight joint (fig. 16, B); or coal-tar pitch should be poured in to plug up the crevice or frame.



FIGURE 14.—Impressed pellets of excrement of nonsubterranean termites (*Kalotermes* sp.), which drop from infested wood. Greatly enlarged.

walls and wooden flooring should be filled in by rounding off the concrete at these places, since cracks often occur where the wall and floor join at right angles (fig. 16, B). Termites often come up through cracks between walls and flooring.

By mixing a heavy mineral residual oil with portland cement, a material is formed almost perfectly nonabsorbent of water and therefore excellent for use in damp-proof construction. Where the various patent or noiseless floorings are used on the ground floor they should always be laid over a concrete base, especially if they contain wood fiber as a constituent.

In no case should untreated beams be completely surrounded with mortar or brick; there should be a space around them sufficient to permit air circulation. Beams should not be set in earth or in moist concrete, but on rock or dry concrete, or in grooves in the latter.

Bungalows or frame buildings which have no cellar should be raised from the ground on stone, concrete, or brick foundations to a height which will allow light and air to penetrate beneath.

LIME MORTAR

Lime mortar sometimes disintegrates after a few years, and termites penetrate through the spaces thus left between the bricks, tiles, etc. Where lime mortar is used below the ground level (fig. 17) the walls should be faced with portland cement 1 inch thick, especially if untreated wood is to come in contact with the bricks.

USE OF CHEMICALLY TREATED WOOD FOR INTERIOR WOODWORK, FURNITURE, ETC.

In the Southern States, especially in the subtropics, in the more valuable permanent buildings the interior woodwork, furniture, etc., should be impregnated with preservatives, since nonsubterranean termites that attack wood directly are common in those regions. Zinc chloride and chlorinated naphthalene⁵ are effective preservatives.

Wood-pulp or fiber products, such as the various wood-fiber processed or composition wall and insulating boards, for interior finish

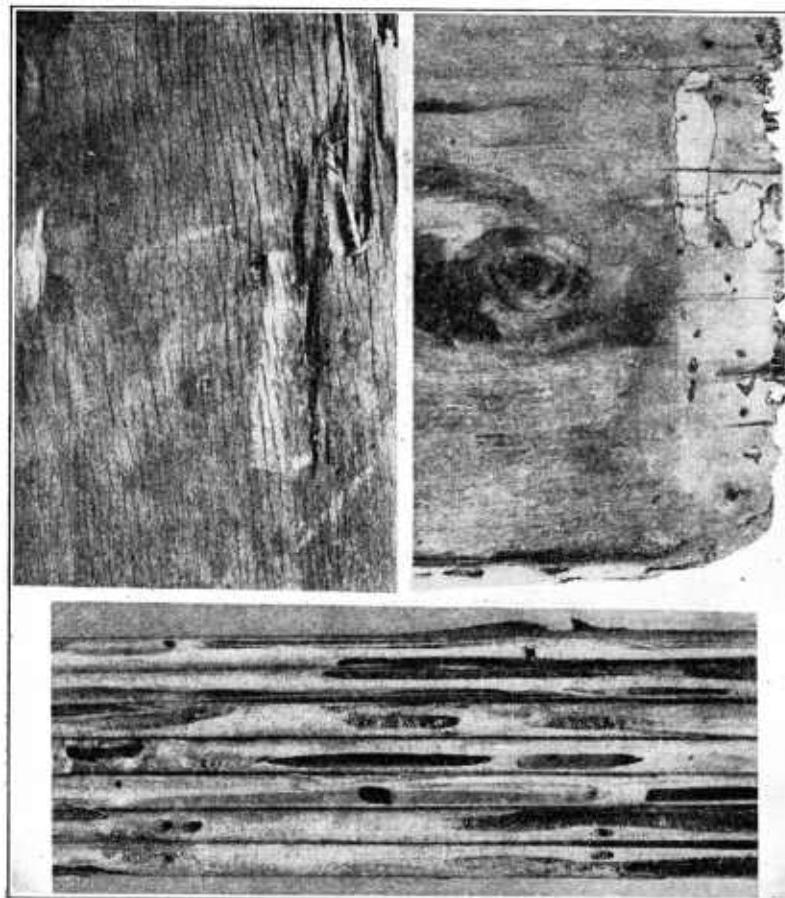


FIGURE 15.—The bottom of a bureau drawer, damaged by the nonsubterranean wood-boring termite *Cryptotermes brevis*, which occurs at Key West, Miami, and Palm Beach, Fla.

and substitutes for lath (fig. 18), or for exterior use, can be protected from attack by termites by adding certain poisons (such as coal-tar creosote at the rate of 2 gallons per 1,000 square feet) to the pulp or fiber laminated boards in the course of manufacture. Experiments with poisoning such products are not yet complete enough to warrant the giving out of definite general recommendations.

⁵ This preservative is usually referred to as trichlornaphthalene and, as compared with other chemicals, it is really comparable to a technical product having naphthalene, monochlornaphthalene, dichlornaphthalene, and probably some of the higher chlorinations as impurities. Its melting point ranges between 190° and 210° F.—the specification under which it is sold.

CITY BUILDING CODES

Urban communities can do much to prevent termite damage by including in their building regulations or codes a few simple provisions which, if enforced, will protect houses from termites. Some cities now have such rules governing the construction of buildings, which have proved very helpful. The Bureau of Entomology will gladly supply information that will aid in drafting suitable regulations.

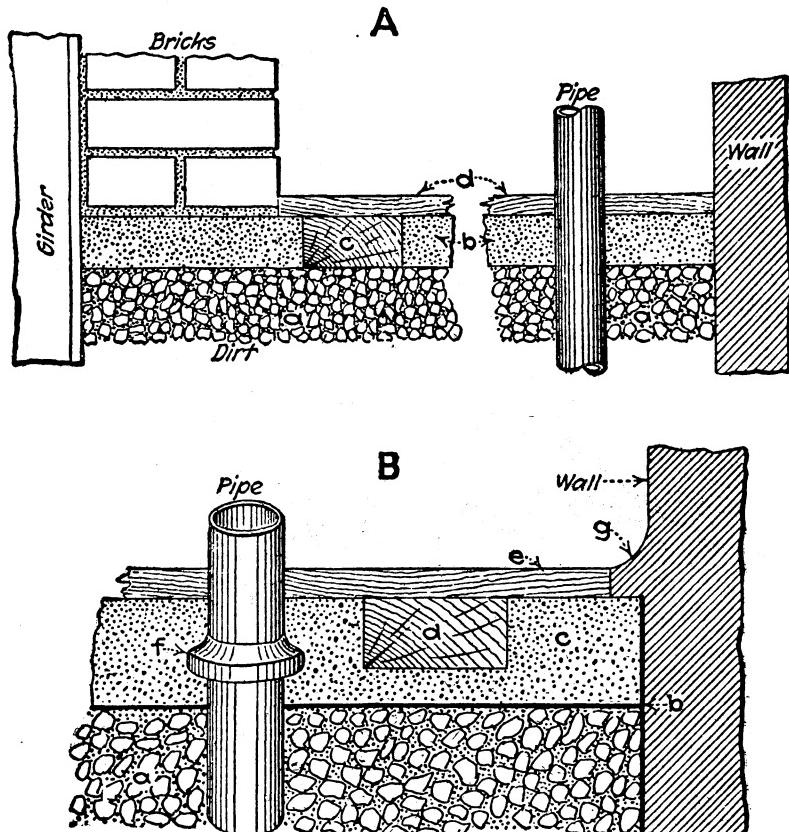


FIGURE 16.—A, Improperly constructed concrete flooring: *a*, Gravel or cinders loosely cemented with coarse concrete, 3 inches thick, but with many crevices and holes; *b*, solid, dense concrete, 2 inches thick; *c*, 2- by 4-inch untreated wood sleeper set in moist concrete over the grout; *d*, $\frac{3}{8}$ -inch pine flooring nailed to sleepers. B, Properly constructed concrete flooring: *a*, Gravel or cinders loosely cemented with coarse concrete, but with many crevices and holes; *b*, coal-tar pitch waterproofing $\frac{3}{8}$ inch thick; *c*, dense concrete, 3 inches thick; *d*, 2- by 4-inch treated wood sleeper set in a groove in concrete which insulates it from termites in the earth; *e*, $\frac{3}{8}$ -inch flooring nailed on sleepers; *f*, metal collar around pipe which runs down through the concrete (this collar should be soldered to the pipe and embedded in the concrete); *g*, shoulder of concrete at point of wall and concrete floor to avoid a right-angle connection and consequent cracking.

The principal object is to keep all untreated wood from contact with the ground, where the termites live and from which they get their moisture. The regulations should, therefore, stipulate that no floors, sills, beams, clapboard, etc., of untreated wood may be laid on or in the earth and that untreated beams may not be laid in concrete without at least 1 inch of concrete underneath and separating it from the earth; that no lime mortar may be used in foundations or in cellar

walls where they are in contact with the earth, since termites are able to penetrate lime mortar⁶ after some years' service; that all brickwork extending below the surface of the ground shall be faced and capped with concrete at least 1 inch thick; and, where nonsubterranean as well as subterranean termites occur, that only woodwork impregnated with preservatives be used for exterior and interior construction, unless it is impracticable to obtain such treated wood. Sun parlors, porches, steps, etc., in places where there is an earth fill, should be isolated from the main building. For further details see United States Department of Agriculture Leaflet 101, Injury to Buildings by Termites.

LOCATING AND TEMPORARILY ARRESTING THE DAMAGE

Although it may be difficult to eliminate termites and stop further damage by them, when once these insects have become established in



FIGURE 17.—Interior view of portion of whitewashed brick foundation wall of building, below ground level, showing shelter tubes of our common subterranean termite *Reticulitermes* sp., penetrating the disintegrated lime mortar. These termites came through the earth banked up against the exterior wall. To remedy this condition the exterior wall will have to be faced with concrete for some distance below the ground level.

the woodwork of a building, the approximate point of entrance should be sought at once by careful examination of all woodwork in contact with the ground. To do this, it may be necessary to tear up the foundations, flooring, and some other woodwork. The foundation timbers and interior woodwork found damaged should be removed, and the ground where they were set should be broken up and drenched with orthodichlorobenzene at the rate of 1 gallon per 10 linear feet, which will kill or at least temporarily prevent the further activity of termites at that point.

⁶ The Bureau of Standards of the U.S. Department of Commerce recommends a mortar composed of 1 part portland cement to 3 parts of sand graded from fine to coarse, with no grains larger than will pass through a no. 10 sieve, to which may be added 10 percent by weight of the cement of some workability agent, such as hydrated lime, for use in locations where termites abound. Such a mortar, it is believed, will have the desirable properties of both cement and lime mortars and, furthermore, will contain a sufficient quantity of cement to prevent the penetration of it by the termites (fig. 17).

INDICATIONS OF INFESTATION

The emergence of large numbers of the flying termites is an indication as well as a warning that the woodwork is infested, and the point of emergence indicates the approximate location of the infested timbers. Large numbers of the dead winged adults or of the discarded wings will usually be found near infested timbers following swarming. Frass and earth thrown out of crevices through which the insects emerge are also evidences of their presence. The presence of branching shelter tubes of small diameter, made of earth mixed with finely powdered wood, on foundation timbers or other woodwork, or over

the surface of stone, brick, or other impenetrable foundation material (fig. 13), through which the insects travel from the ground to the woodwork, is another aid in locating infestations. These tubes should be broken off and the ground where they originate broken up and drenched with one of the liquids named in the paragraph under the heading, Destruction of Breeding Places about the Building Site (p. 7).

In the case of the nonsubterranean termites, which infest wood directly, evidences that they are damaging wood are the impressed pellets of excrement (fig. 14) which are expelled from the wood. Other evidences are

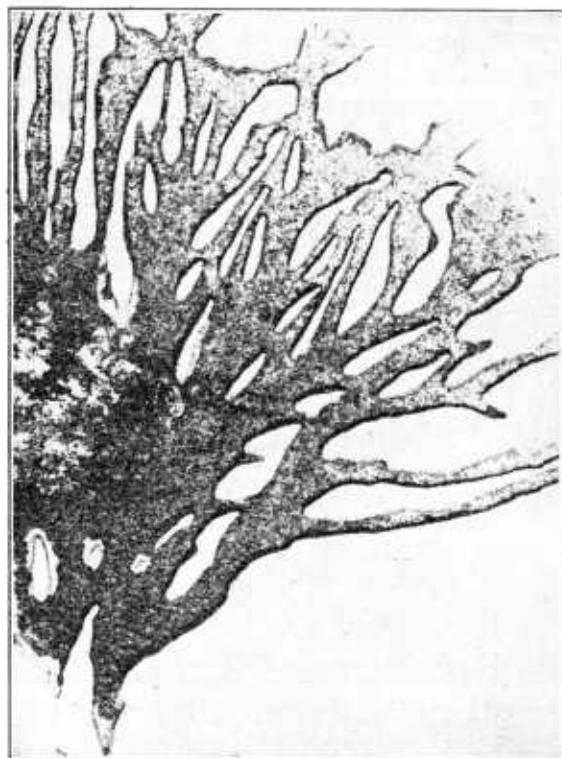


FIGURE 18.—Pressed wood-pulp tile mined by subterranean termites infesting the building, Biloxi, Miss.

the holes, similar in size to BB shot, where the insects entered the wood (fig. 19).

KILLING THE WINGED ADULTS WILL NOT STOP THE DAMAGE

When efforts are made to prevent further damage by termites in buildings, it should be realized that the numbers of these insects may be constantly recruited from some undiscovered, outside, central colony. The destruction of the winged colonizing adults at the time of emergence, although beneficial in preventing the establishment of new colonies, out of doors, will not eradicate the insects infesting the woodwork. These winged adults are harmless indoors and will soon

die. Sweeping them up with a vacuum cleaner is a simple method of getting rid of them. The most destructive forms are the white, wingless workers, which remain within the wood.

DISCONNECTING WOOD FROM THE GROUND

Subterranean termites infesting beams or other wood will die if the wood is disconnected from the ground. Knowledge of this fact will save time and expense, especially in the case of old frame buildings, where extensive repairs would be unwarranted. Disconnecting untreated foundation timbers from contact with the soil will also cause the death of subterranean termites in the other wood-work, furniture, and stored material in the building, even if they have penetrated to the second or third floors. These timbers need not be removed or replaced unless seriously weakened structurally. However, if the wood is kept moist by some other means, such as water leakage, the termites will continue to work and thrive. This applies especially to damp corners of basements near outside water pipes, bathrooms, kitchens, and the like.

REPLACING WOOD WITH CONCRETE

Concrete floors and concrete baseboards should be substituted for wood. Untreated beams penetrating through concrete floors into the earth and the lower parts of door jambs and casings should be cut off at least 6 inches above the ground or floor and replaced with cement plinths, which should project one quarter inch beyond the jambs and casings. Metal strips should be sunk down from the woodwork into the concrete. Wooden thresholds, wainscoting, window sills, subsills, and stools in the basement or ground floor should be removed and placed on concrete (a layer of concrete between the earth and wood (fig. 16, B)) or replaced with concrete.

REPLACING WOOD WITH METAL

In basements and cellars steel rails or other structural metal work can sometimes be economically used to replace weakened timbers.

COMBATING TERMITES THAT ARE NONSUBTERRANEAN IN HABIT

Unlike the subterranean termites, nonsubterranean termites do not live in the soil, but fly to and attack wood directly. To combat such termites it is advisable to remove and replace the wood if the



FIGURE 19.—Entrance holes of sexual, colonizing adults of a nonsubterranean termite (*Kalotermes hubbelli*) in wood of dead cottonwood tree in Arizona.

damage is slight and localized. Where the wood has been seriously damaged, but not structurally weakened, saturate the infested wood with orthodichlorobenzene. The wood should be thoroughly saturated with this chemical, a rag or mop being used, dripping wet, or the liquid can be applied as a spray. Several applications may be necessary to kill the insects.

If orthodichlorobenzene is used as a spray, it is advised that the house be opened up before and for some time after treatment, since there is quite an odor to the chemical which may prove disagreeable in a closed room. Also, in spraying timbers overhead care should be taken not to let the liquid drip down, since it might slightly burn the face and hands and would be painful if it got into the eyes.

If the orthodichlorobenzene treatment is not practicable and the wood is too thick for the solution to penetrate, blow dry paris green, or the less dangerous although less effective sodium fluosilicate, by means of a bellows into holes bored with an auger into the infested wood; these holes should penetrate to the galleries of the termites. If, because of moisture, the powder becomes caked, the treatment should be repeated. Wood structurally weakened should be removed and replaced with chemically-treated wood or strengthened with structural steel.

By far the greater and more serious damage to timber in the United States is caused by termites of the subterranean type. Department of Agriculture Leaflet 101, on the prevention of damage by termites in buildings, discusses in detail the control of subterranean termites infesting buildings.

PREVENTING AND REMEDYING INJURY TO LIVING VEGETATION

FRUIT, NUT, SHADE, AND FOREST TREES

Termites cause occasional but serious injury to individual living trees, shrubs, nursery stock, and grapevines. In case of shade trees the infestation may start as local at the base and extend more generally through the heart wood. A wise preventive measure is the removal of all loose wood which may afford them shelter, such as prunings, dead and dying trees, and the like, and untreated fence posts and similar material.

Termites are also occasionally a pest in orchards, not only in new orchards planted on freshly cleared land where there is such debris, but also, because of neglect, in old orchards, in both Florida and California.

Cleanliness in orchard and forest management is important. Since termites in the Southern States render unmerchantable the forest trees that have been killed by insects, fire, or disease, all timber from such trees should be utilized or removed as promptly as possible in areas where termites are common.

In the case of the pecan it is recommended that 2 or 3 cereal crops be grown on newly cleared land before the young trees are set out.

TREE SURGERY

Properly executed tree surgery sometimes is effective in repairing injury by termites to valuable old fruit and shade trees. The termite-infested wood should be carefully cut out, and the dead heartwood should be given a brush treatment with coal-tar creosote. This

treatment should not extend to within an inch of the living sapwood. Then the cavity should be filled with a suitable material.

COVERING SCARS AND PRUNED AREAS

To prevent infestation, care should be taken that the trees do not become scarred, especially near the base. Scars and all pruned areas should be treated with a mixture of one fourth creosote and three fourths coal tar. This mixture should not be allowed to come in contact with the living tissues at the edges of the bark; to protect them a shellac should be applied.

COMMERCIAL FERTILIZERS

Soil heavily manured will attract subterranean termites, since they can obtain food from the animal manure; commercial fertilizers should be used in preference in regions where termites are common in the soil.

YOUNG PLANTATIONS OR NURSERY STOCK

Injury to nursery stock from 1 to 3 years old will be more serious on recently cleared land and where decaying wood is abundant. Any debris in which the insects breed should be removed. In general the use of recently cleared land should be avoided in planting nursery stock. Earth used in banking should be free from rotten wood. Care should be taken not to allow the roots to dry out before being planted, as weakened stock is specially susceptible to attack; particular care should be given grafted stock.

INSECTICIDES

When valuable trees are infested but not yet dying, subterranean termites can be killed in the soil, if it is moist and not too compact, by breaking it up near the tree and pouring carbon disulphide on the earth at a distance of about a foot from the trunk, then covering the liquid over with earth. The gas from this liquid will penetrate the subterranean galleries of the termites. It is somewhat dangerous to plant life, and very large doses should not be used. *Care should be taken in handling this volatile fluid, as the gas or vapor from it is highly inflammable and explosive when mixed with air in certain proportions; no flame should be brought near it, and the fumes should not be inhaled, as they are poisonous.* There are indications that an emulsion of carbon disulphide, which is on the market ready for use, may prove more effective than carbon disulphide alone; as in the case of the disulphide itself, the earth is loosened up and the emulsion poured on, at least a foot from the tree. Carbon tetrachloride,⁷ the gas from which is neither explosive nor inflammable, can be similarly used but is apparently not so effective as carbon disulphide. The gases from carbon disulphide and carbon tetrachloride, being heavier than air, will not readily rise.

Where nonsubterranean termites are infesting living trees, they can be poisoned with dry paris green in the manner discussed on page 18.

⁷ Carbon tetrachloride is a thin, transparent, colorless, volatile liquid, which forms a gas with a pungent, aromatic odor. Like carbon disulphide, it is heavier than air. Although it is only about one half or one third as effective as carbon disulphide when used at the same dosage rate, it has the great advantage that its gas is neither explosive nor inflammable; there will be no fire risk attending its use in buildings.

VINEYARDS

In vineyards all dead or diseased vines should be removed. All exposed areas left by pruning should be painted with preservative coatings, and the prunings should be burned promptly. Nearby stands of tree windbreaks should be carefully cared for and kept free from infestation by termites. Trellis posts should be creosoted.

FIELD AND TRUCK CROPS**DEEP FALL PLOWING**

Deep, late, fall plowing will be of value in breaking up the galleries and nests of subterranean termites on ground planted to field or truck crops. Irrigating the land, where practicable, will be effective; this can be done before planting the crop.

BURNING STUBBLE

Care should be taken not to plow under stubble which will serve as food for termites; it should be burned. The use of commercial fertilizers instead of animal manure is also recommended where subterranean termites are common in the soil.

ROTATION OF CROPS

As a result of the frequent stirring of the soil, rotation of crops will aid in preventing termites from injuring them. Plowing and fallowing are more practical than the use of insecticides in preparing the soil to prevent termite damage.

FLOWERS AND GREENHOUSE STOCK

Termites injure a great variety of flowers in gardens, as well as many plants grown under glass in greenhouses, where the warm, moist atmosphere maintained throughout the year promotes greatly the activity of the insects. Injury from termites is especially common where the plants are perennial and have woody stalks.

SOURCES OF INFESTATION

Heavily manured flower beds are a source of infestation to the stems of the flowers, as well as to the woodwork of buildings near by, if suitable protection is lacking. Termites can obtain food from the animal manure. Untreated wooden stakes used as supports of plants often become infested, and in time the insects attack the plants. Where greenhouses have already been built and termite damage is due to poor construction termites often attack old label sticks, the wooden uprights supporting wooden benches set on or in the ground, and the wooden bench bottoms and plant pots, and later attack the growing plants. The insects come up through the ground and form dirt galleries over the supports, or burrow up through the wooden bench legs and run galleries the full length of the benches. They enter the soil in the pots through the drainage holes and eat out the main stalk of the root, killing the plant very quickly.

PROPER CONSTRUCTION OF GREENHOUSES

Proper construction of greenhouses will practically safeguard plants growing in them from all injury by termites. Iron frames and concrete work should, wherever possible, replace bricks or woodwork.

In cases of infestation of old greenhouses, all wooden uprights supporting wooden plant benches should be sawed off, if set on or in the ground, and rested on stone, bricks, or concrete, above the surface of the ground. Proper repairing, including the removal of all infested wood, will prevent the plants from becoming infested in turn. Where woodwork is necessary the wood should be impregnated with zinc chloride or bichloride of mercury; it can be painted after treatment. Wood impregnated with coal-tar creosote cannot be used with safety in greenhouses.

AVOIDING STABLE MANURE

In flower gardens, especially those located near the woodwork of buildings, commercial fertilizer should be substituted for stable manure in order to protect not only the buildings but also the growing plants.

INSECTICIDES

Either carbon disulphide or carbon tetrachloride⁸ can be used to kill termites in the soil if it is moist and not compact. These gases should not be used too near the infested plants, or the plants should be removed temporarily until the soil has been treated. Small holes should be made near the infested plants and a small quantity of the liquid chosen poured in and the holes immediately closed tightly with earth. Calcium cyanide⁹ has also been found effective, but it should not be placed near living plants; it mixes readily with and enriches the soil and gives off an insecticidal gas which *should not be inhaled, as it is poisonous.*

An effective control may be found in the use of kerosene nicotine oleate or a 5-percent kerosene emulsion.¹⁰ If the greenhouse benches are infested, but for any reason cannot be replaced, they should be soaked thoroughly with this emulsion, as should also the ashes and sand under the pots on the benches. This may be done by removing the potted plants from a section of the bench, spraying that section, and moving the pots on the bench to cover the treated area, thus giving access to another section. Potted heliotropes and geraniums have been treated directly with the 5-percent kerosene emulsion without injury to the plants, and the white ants in the soil of the pots were all killed. The soil should be wet down before this spray is used. This treatment should be given late in the afternoon and be followed early the next morning with a thorough syringing of the soil with water to wash out the surplus oil. It is important to remove all infested pots from the bench as soon as the infestation is noticed and to destroy the termites with kerosene emulsion.

⁸ See footnote 7 (p. 19).

⁹ 2 ounces of calcium cyanide to 1 square yard of ground is recommended.

¹⁰ Kerosene emulsion is made as follows: Kerosene, 2 gallons; fish-oil soap, $\frac{1}{2}$ pound; water, 1 gallon. Dissolve the soap in hot water and pour in the oil slowly, with constant stirring to emulsify. Dilution: If 37 gallons of water be added to the above stock emulsion it will give 40 gallons of 5-percent kerosene emulsion.

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